CHAPTER

11 Tiebacks, Tiedowns, and Soil Nails

Tiebacks

Tiebacks are used in both temporary and permanent structures. The use of tiebacks with sheet pile or soldier beam shoring permits higher walls and deeper excavations than are possible with cantilever type construction—up to 35 feet or so versus 15 feet for cantilever construction. Walls higher than 35 feet can be built by using high strength sheet pile or soldier beams with additional tiers of tiebacks.

Components

A tieback consists of the following components as shown in Figure 11-1:

COMPONENT	DESCRIPTION
Bond Length	The portion of prestressing steel fixed in the primary grout bulb through which load is transferred to the surrounding soil or rock. Also known as the anchor zone.
Unbonded Length	The portion of the prestressing steel which is free to elongate elastically and transmit the resisting force from the bond length to the wall face.
Prestressing Steel – Support Member	This transfers load from the wall reaction to the anchor zone and is generally a prestress rod or strand.
Anchorage	This consists of a plate and anchor head or threaded nut and permits stressing and lock-off of the prestressing steel.
Grout	This provides corrosion protection as well as the medium to transfer load from the prestressing steel to the soil or rock.

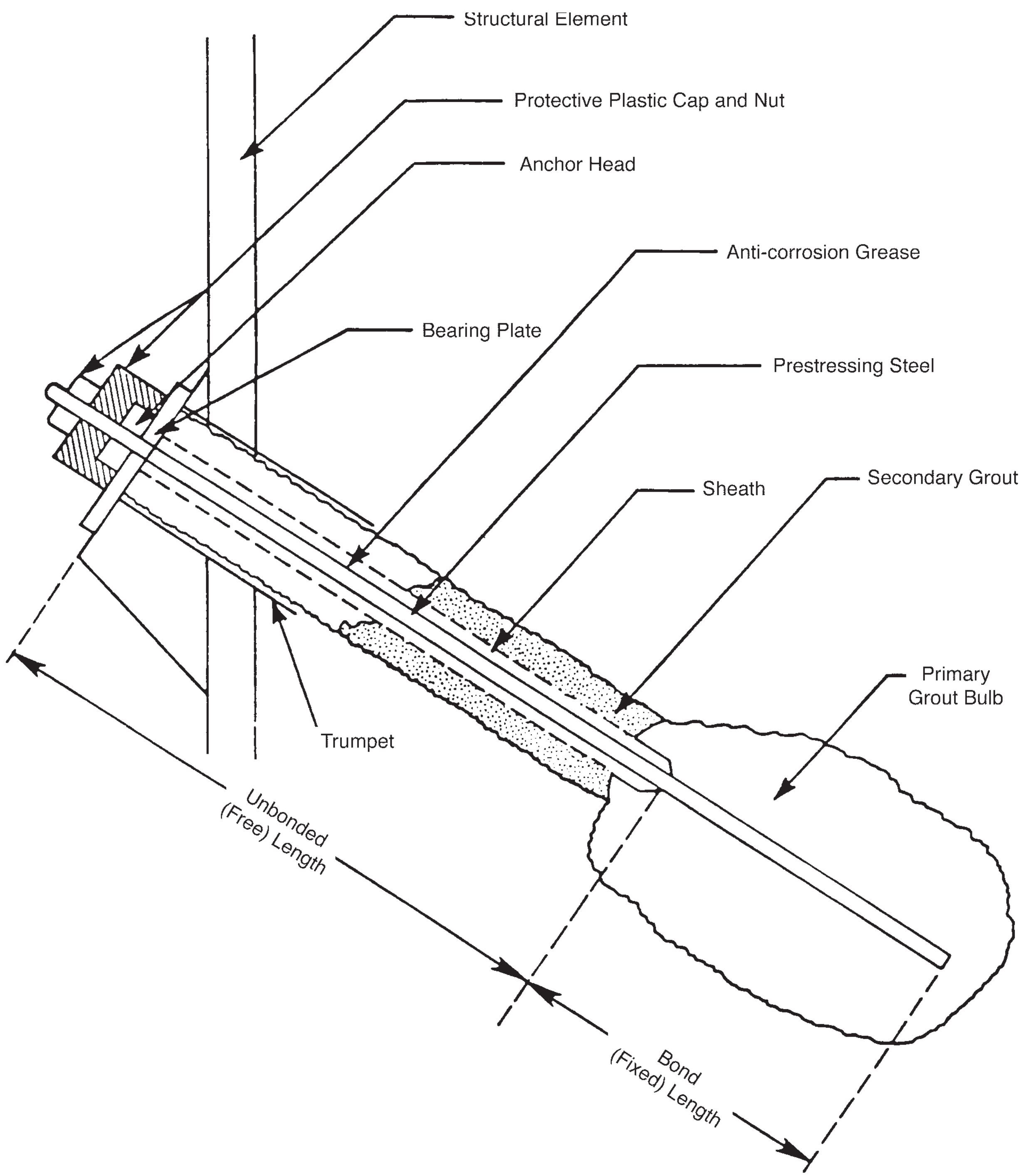

Figure 11-1: Tieback Detail

In addition to allowing higher wall designs, tiebacks serve another useful purpose. The only part of the system that projects beyond the wall into the excavation is the relatively small anchoring device. Hence, the system provides an open unrestricted work area in the excavation.

Tieback shoring designs require sophisticated engineering techniques and the calculations submitted by contractors and consultants can therefore be very complex.

For permanent structures, the Contractor is responsible for providing the tieback system which conforms to the design requirements shown on the plans and the testing requirements specified in the contract documents. The Contractor has the option of choosing which system will be installed. The record of readings from the Performance and Proof tests shall be documented by the Contractor and provided to the Engineer.

A Tieback Technical Specialist is available for consultation and is located in the Office of Structure Construction in Sacramento. In addition, the Staff Specialist for Earth Retaining Systems in the Office of Structure Design in Sacramento can be helpful in answering any questions that may arise.

Specifications for tieback anchors are generally found in the contract Special Provisions. Tieback anchors shall be installed in accordance with the manufacturer's recommendations. In case of a conflict between the manufacturer's recommendations and the Special Provisions, the Special Provisions shall prevail.

Sequence of Construction

Sequence of tieback construction is as follows:

SEQUENCE	DESCRIPTION
1	Drill the holes the required length and diameter.
2	Install the prestressing strands or bar.
3	Place primary grout.
4	Complete Performance and Proof Tests (refer to section on testing later in this chapter).
5	Lock-off and stress.
6	Place secondary grout.

Note: Each step must comply with the contract specifications before proceeding to the next step.

Safety

Check the Contractor's construction sequence against the approved plans. As excavation proceeds from the top down, look for signs of failure in the lagging or changes in the soil strata.

Tiedowns

Tiedowns are commonly used in footings on seismic retrofit projects. They are used to provide additional restraint against rotation of the footings and can be installed in both soil and rock. Tiedowns and tiebacks are constructed similarly but differ in their angle of reference. Tiedowns are installed with reference to a vertical zero angle, whereas tiebacks are referenced to a horizontal zero angle.

An example of a prestressing bar tiedown anchor is shown in Figure 11-2.

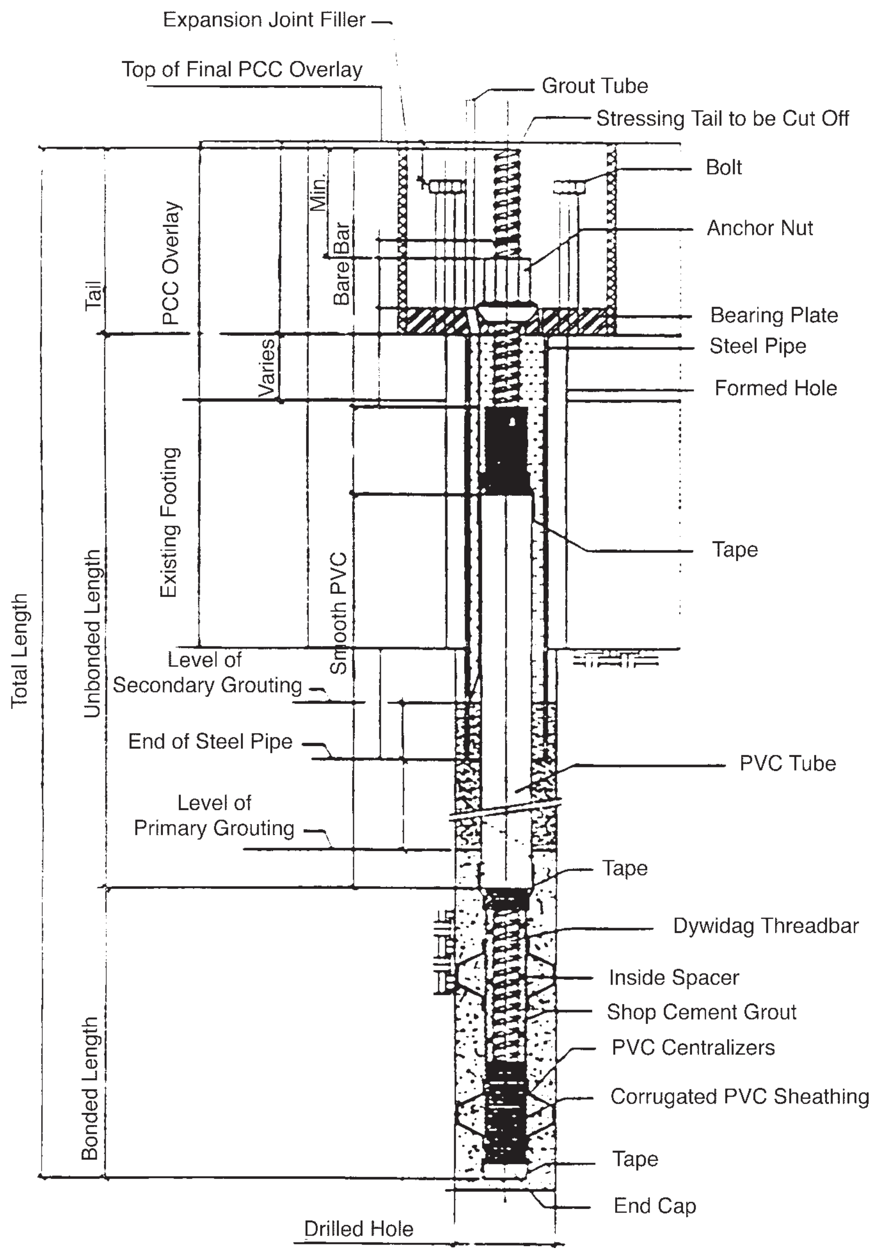

Figure 11-2: Tiedown Anchor

The Contractor is responsible for providing the tiedown anchor system which conforms to the design requirements shown on the plans and the testing requirements specified in the contract documents. The option of choosing which system will be installed is left to the Contractor. The record of readings from the Performance and Proof tests shall be documented by the Contractor and provided to the Engineer.

Specifications for tiedown anchors are generally found in the contract Special Provisions. Tiedown anchors shall be installed in accordance with the manufacturer's recommendations. In the case of a conflict between the manufacturer's recommendations and the Special Provisions, the Special Provisions shall prevail.

Sequence of Construction

Sequence of tiedown construction is as follows:

SEQUENCE	DESCRIPTION
1	Drill the hole the required depth and diameter.
2	Install the prestressing strands or bar.
3	Place primary grout.
4	Complete Performance and Proof Tests (refer to the section on testing later in this chapter).
5	Lock-off and stress.
6	Place secondary grout.

Note: Each step must comply with the specifications before proceeding to the next step.

Testing of Tieback and Tiedown Anchors

The specific requirements for all testing will usually be provided in the contract Special Provisions, but the following is a general explanation of the required tests.

For both tiedowns and tiebacks, Performance tests are performed on a predetermined number of anchors, and Proof tests are done on all of the anchors. If the systems should fail, the contract Special Provisions provide for additional monitoring requirements. If they do not pass at that point, the Project Designer should be consulted.

Performance Tests

A Performance test involves incremental loading and unloading of a production anchor to accurately verify that the design load may be safely carried, that the free length is as specified, and that the residual movement is within tolerable limits. As a minimum, the first two production anchors installed should be Performance tested. Do not wait until many anchors are installed before testing the first two anchors. The purpose of these tests is to verify the installation procedure selected by the Contractor before a large number of anchors are installed. Each load increment or decrement shall be held constant for at least one minute or until measured deflection is negligible. The maximum load should generally be held for one hour to determine long-term creep susceptibility. As was stated earlier, the contract plans and/or Special Provisions should specify the number of Performance tests be performed at each location.

Proof Tests

A Proof test involves incrementally loading a production anchor to verify that the design capacity can be safely carried and that the free length is as specified. The Proof test is a single cycle test where the load is applied in increments until the maximum load value is reached. Each load shall be held constant for at least one minute or until measured deflection is negligible.

General Acceptance Criteria

CRITERIA	DESCRIPTION
1	The deflection at the anchor head should exceed 80% of the theoretical free length elongation for any test load.
2	The total deflection measured at the maximum test load does not exceed the theoretical elongation of a tendon length.
3	The creep movement does not exceed 0.08 inch during the final log cycle of time.

General Construction Control

ITEM	DESCRIPTION
1	Mill certs should be provided for the steel tendons. a) Check the steel for damage. b) Ensure that grease completely fills the free length plastic tube. c) Securely tape the bottom of the free length. d) Compare the actual free length dimensions versus the dimension specified.
2	Double corrosion protection anchors should be completely fabricated before being delivered to the job site. Bar anchors are installed full length into the hole. Record the actual free and bond length for each installed anchor.
3	Tendons shall be equipped with centralizers. These centralizer devices are absolutely necessary to center the tendon in the hole and to prevent the tendon from laying on the side of the hole where incomplete grout cover will cause loss of capacity and future corrosion.
4	Grout tubes are frequently tied to the tendon before inserting in the hole. This helps to ensure that there are no voids in the grout.
5	Testing – check to ensure the tendon is concentrically located in the center hole jack and load cell before testing begins. Poor alignment of the testing apparatus will cause eccentric loading on the load cell and jack, which will give erroneous readings. Deflections at the anchor head should be measured with a dial gauge.

Soil Nails

Soil nailing is a technique used to reinforce and strengthen an existing embankment (Figure 11-3). The fundamental concept is that soil can be effectively reinforced by installing closely spaced grouted steel bars, or "nails", into a slope or excavation as construction proceeds from the top down. The nail bars are not pre-tensioned when they are installed. They are forced into tension as the ground deforms laterally in response to the loss of support caused by continued excavation. The grouted nails increase the shear strength of the overall soil mass and limit displacement during and after excavation. Soil nails are bonded along their full length and are not constructed with a permanent unbonded length as are tieback anchors. A typical soil nail is shown in Figure 11-4.

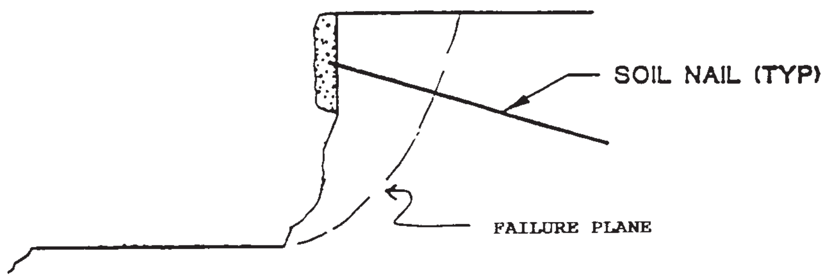

Figure 11-3: Soil Nail Schematic

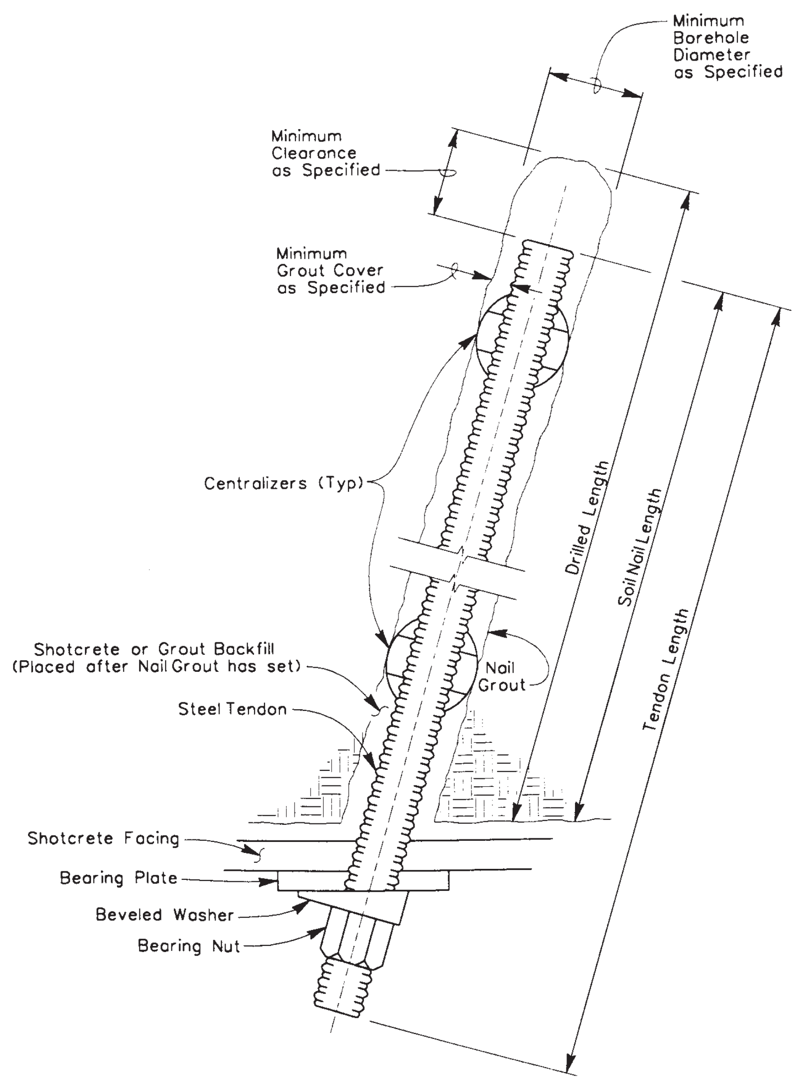

Figure 11-4: Soil Nail Detail

Soil nailing is a cost-effective alternative to conventional retaining wall structures when used in situations with ground formations suitable for nailing.

Common nail wall applications include the following:

APPLICATION	DESCRIPTION
1	Temporary and permanent walls for building excavations.
2	Cut slope retention for roadway widening and depressed roadways.
3	Bridge abutments – addition of traffic lanes by removing end slopes from in front of existing bridge abutments.
4	Slope stabilization.
5	Repair or reconstruction of existing structures.

Soil nail wall construction is sensitive to ground conditions, construction methods, equipment, and excavation sequencing. For soil nail walls to be most economical, they should be constructed in ground that can stand unsupported on a vertical or steeply slope cut of 3 to 6 feet for at least one to two days, and that can maintain an open drilled hole for at least several hours.

Construction Sequence

Soil Nail Wall Construction Sequence is as follows:

SEQUENCE	DESCRIPTION
1	Excavate a vertical cut to the elevation of the soil nails.
2	Drill the hole for the nail.
3	Install and grout the soil nail tendon.
4	Place the geocomposite drain strips, the initial shotcrete layer, and install the bearing plates and nuts.
5	Repeat process to final grade.
6	Place the final facing (for permanent walls).

Engineer's Responsibility

The Structure Representative shall ensure that the soil nail wall is being built in accordance with the contract documents. The Engineer is responsible for reviewing and approving the Contractor's submittal of construction details. The Structure Foundations Branch of the

Office of Structural Foundations is available to assist the Structure Representative in the review of the Contractor's submittal. Prior to construction, the planned alignment, depth, and layout of the soil nails shall be checked in the field for any possible discrepancies.

Contractor's Responsibility

The Contractor is responsible for constructing the soil nail wall in accordance with the contract documents. The Contractor is also responsible for submitting to the Engineer for approval complete details of the materials, procedures, sequences, and proposed equipment to be used for constructing the soil nail assemblies and for constructing and testing the test soil nail assemblies. The Contractor shall furnish a complete test result to the Engineer for each soil nail assembly tested.

Test Nails

Test nails are not production nails and are meant to be "sacrificial". They are installed in the same manner as production nails but have an area that is not grouted or bonded. Pullout tests should be performed before excavation is continued below the level of the test nail. Once the test is performed, the remainder of the drilled hole of the test nail is filled with grout. The location of test nails is determined by the Project Designer and shown on the plans. Refer to Figure 11-5 for a test nail detail.

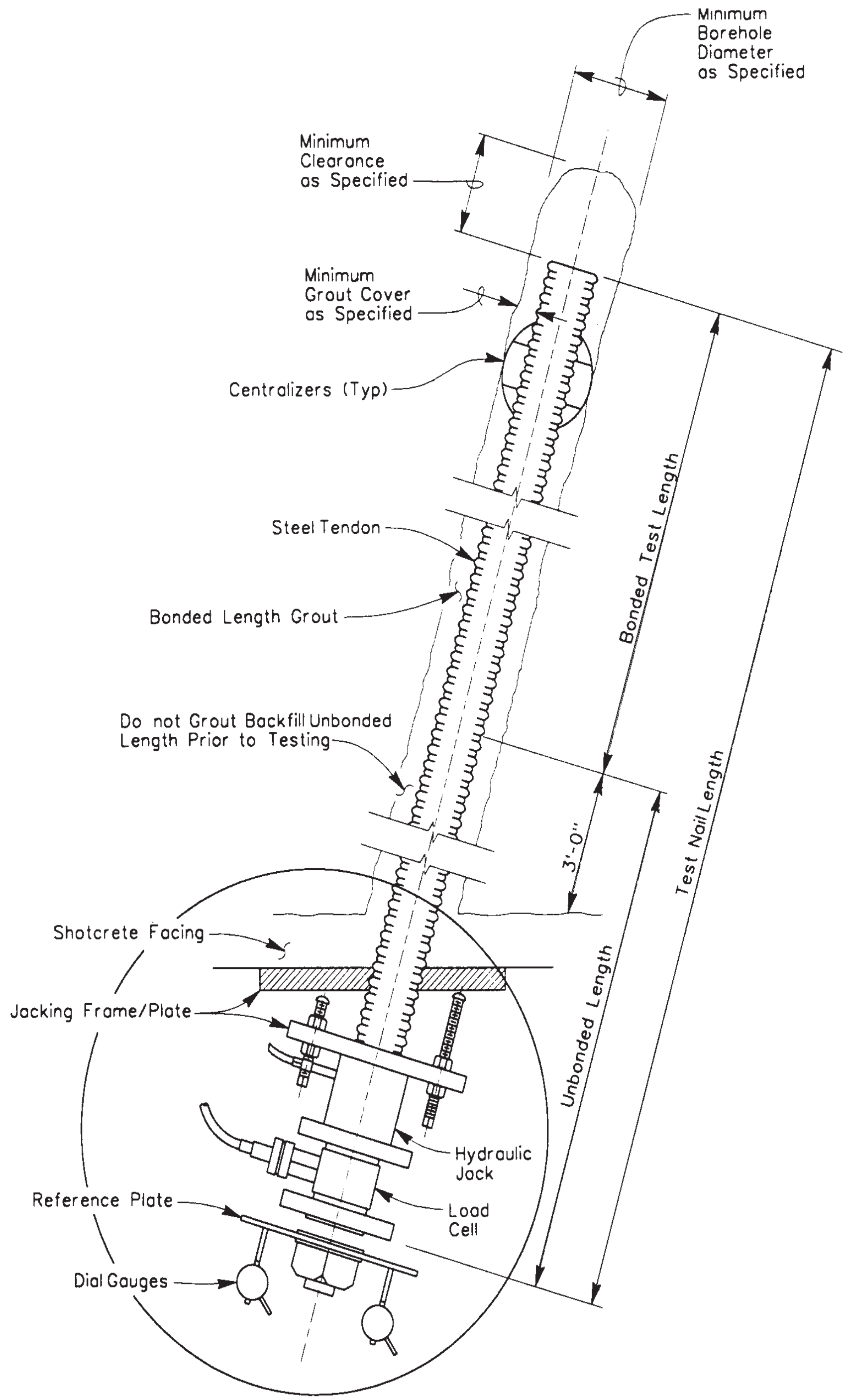

Figure 11-5: Test Nail Detail

Testing

You should refer to your contract documents for specific test requirements for your project. The following is a general description of the required tests.

A pullout test consists of incrementally loading the test soil nail assembly to the maximum test load or the failure point, whichever occurs first. The failure point is the point where the movement of the test soil nail continues without an increase in the load or when the soil nail creep rate exceeds 0.08 inch between 6 and 60 minutes. Movement of the soil nail end shall be measured and recorded to the nearest 0.001 inch at each increment of load, including the ending alignment load, relative to an independent fixed reference point.

The pullout test measuring the test load is applied to the test soil nail and measures the test soil nail end movement at each load. Each increment of load shall be applied in less than one minute and held for at least one minute but not more than two minutes. During the 10 minute load hold, the movement of the end of the soil nail shall be measured at 1, 2, 3, 4, 5, 6, and 10 minutes. After the 0.08 inch creep rate is established, the load is reduced to the final alignment load, and then the soil nail is unloaded. If a test soil nail fails to attain the maximum test load, one or all of the following procedures may be performed: (1) install and test additional test soil nails if the initial test results are believed to be in error, (2) determine if the cause is due to a variation of the soil conditions, installation procedure or materials, or (3) reevaluate the soil properties if differing soil conditions are encountered and redesign the wall if necessary. Any changes necessitated by failing tests shall be approved by the Project Designer.

Safety

The soil nail wall should be monitored during construction for movement and for signs of failure. Occasionally, poor material will be encountered as the excavation continues downward. This differing condition may require a change to the plans or safety provisions in the construction method.